TABLES

FOR

SIMPLE QUALITATIVE ANALYSIS,

BY

H. H. CROFT.

TABLES

FOR
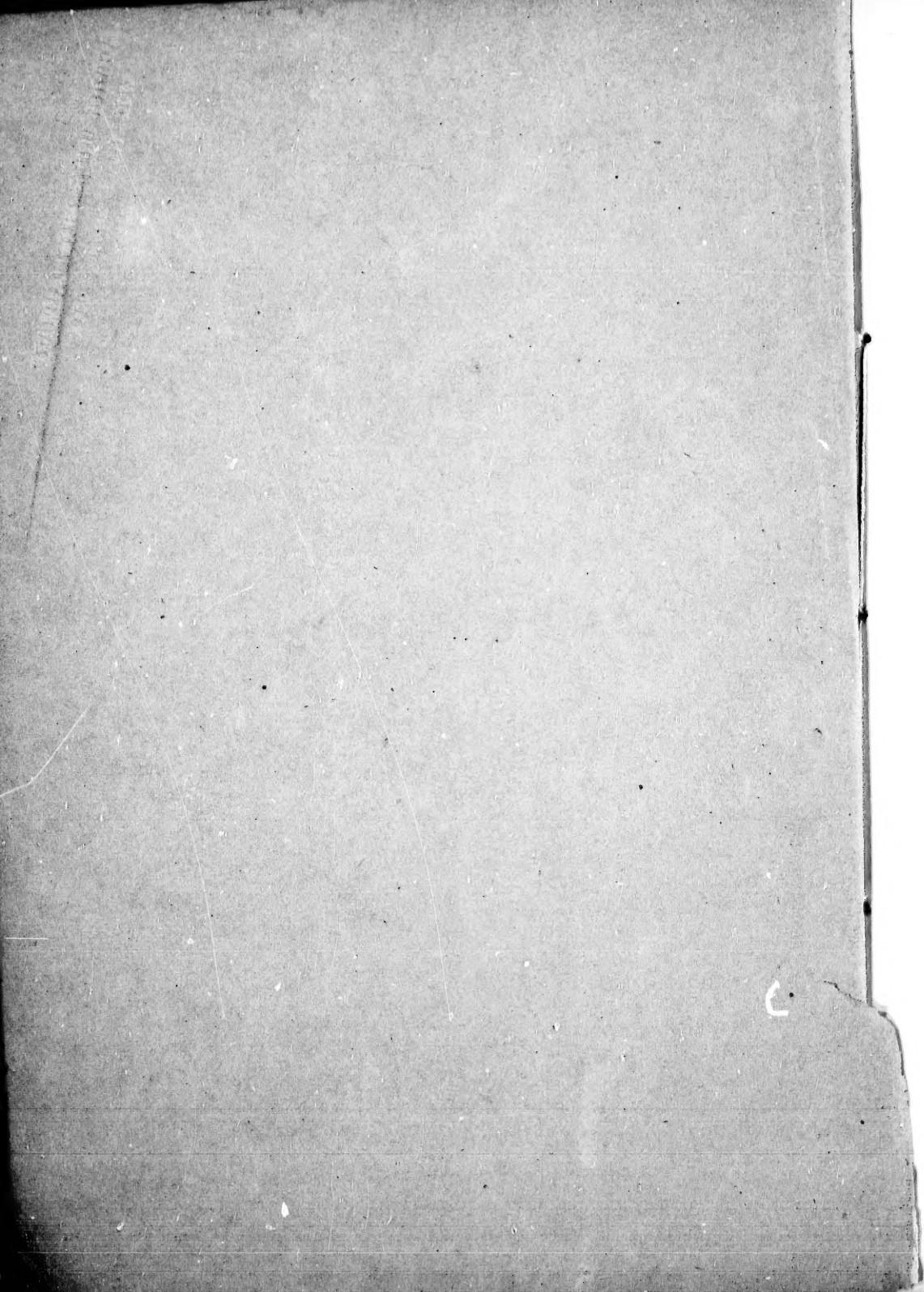
SIMPLE QUALITATIVE ANALYSIS

FOR

LABORATORY USE.

The following tables are intended for practice in elementary chemical analysis, and to apply only to simple salts, consisting of one base and one acid, mostly soluble in water, or of the acids and bases uncombined. Many bases (oxides) are insoluble in water, but can be readily dissolved in nitric or hydrochloric acid; some few acids are insoluble in water, but can be dissolved in potassium hydrate. Some salts are decomposed by water, but solutions can be obtained by adding a little nitric acid, and heating; as little acid should be used as possible. Many salts which are insoluble in water, such as many carbonates, phosphates, &c., may be dissolved in the same way, using either nitric or hydrochloric acid, and the solutions can in most cases be examined in the ordinary manner.

In examining a salt, about one-third should be dissolved in a small quantity of water, and the test tube containing the solution placed always in one particular part of the stand, say the left hand upper hole. A small part of this can be diluted with two or three parts of water in another test tube, and the experiments proceeded with. The *same* solution can be used for the first three groups of Table I. Thus if hydrochloric acid produces no change, pass to Group II., adding three times the bulk of hydrosulphuric acid; if this produces no change, pass to Group III., adding first twice the bulk (of the original solution) of ammonium chloride, then ammonia until it smells strongly after shaking, and, lastly, a *small* quantity of ammonium sulphide, whether any change has been produced by the ammonia or not.
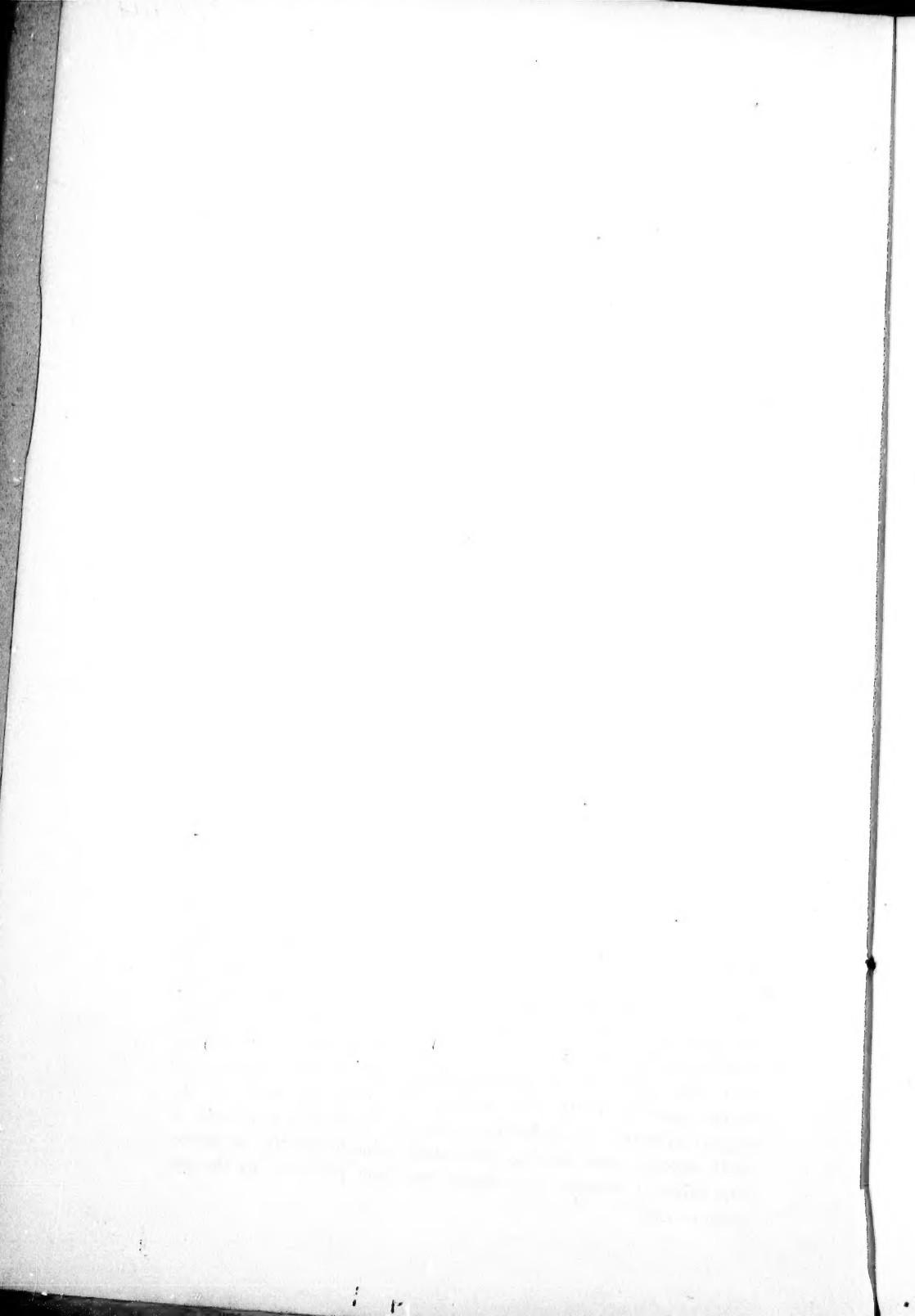
The same solution may be used for Group IV. if the salt does not belong to either of the first three, but it is preferable now to employ some of the original solution. It may happen that no base whatever is found, as would be the case in the examination of acids, and *vice versa*, no acid if the substance is a base. In the case of no metal being found, the base is in all probability hydrogen, which takes the place of true metals in salts, producing acids. When in the investigation for acids none have been found, the compound under examination is probably a hydrate, *i.e.* a combination of an oxide with water. Arsenic is conveniently ranked under both heads.

It is best to commence with the detection of the base, as this knowledge obviates the necessity of searching for many acids, if the substance examined has been found to be soluble in water. Thus lead in an easily soluble salt would exclude hydrochloric, hydriodic, hydrobromic, carbonic, phosphoric, sulphuric acids, &c., &c.

Barium would exclude sulphuric, carbonic, phosphoric acids, &c., &c., but not hydrochloric, hydriodic, or hydrobromic acids, &c.

A knowledge of the solubilities of salts will greatly aid the investigation.
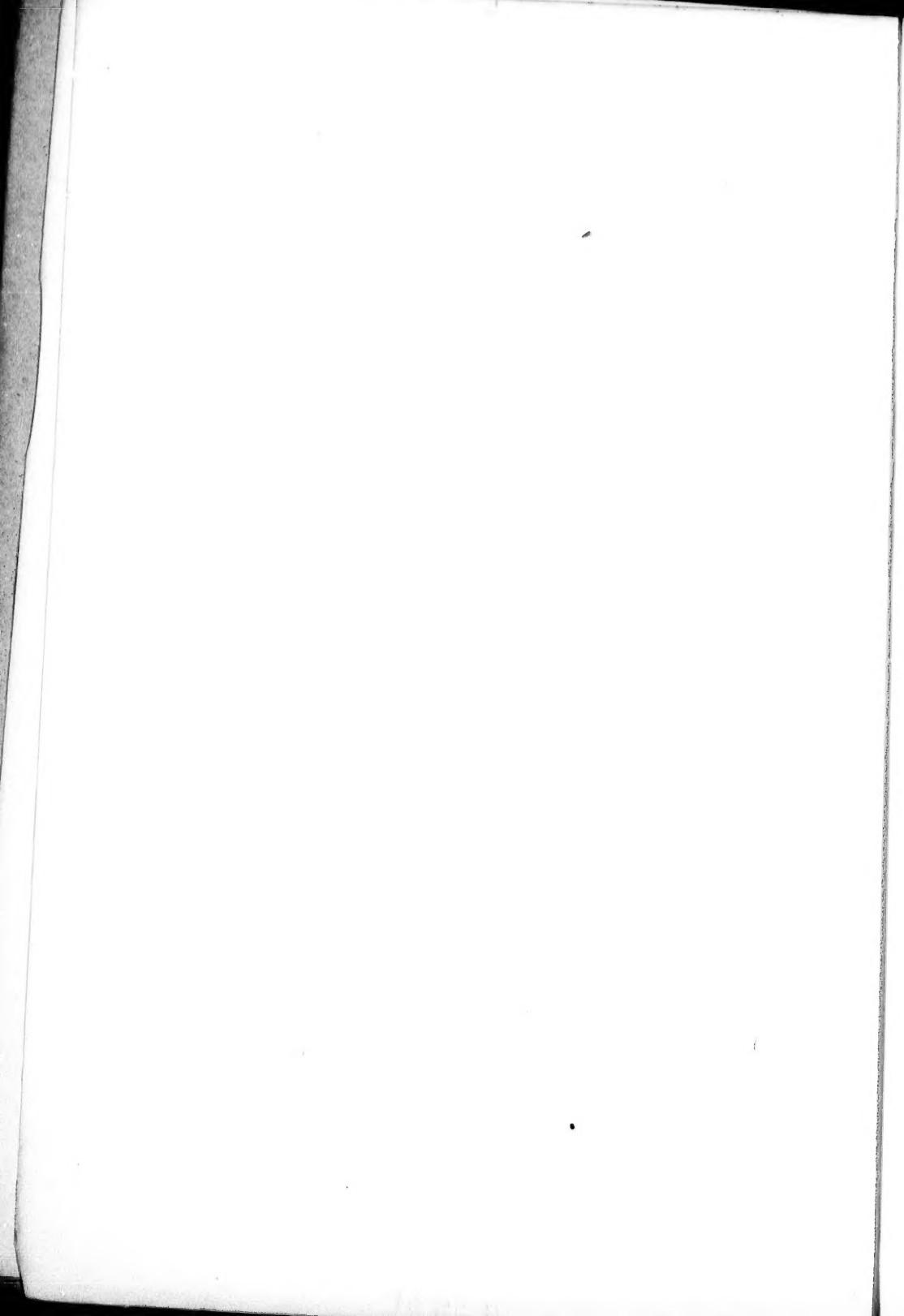
TABLE 1.—BASES.

GROUP I.	GROUP II.	GROUP III.	GROUP IV	GROUP V.
Hydrochloric acid produces a white precipitate, insoluble in excess of the acid. The solution employed should not be very concentrated.	Hydrosulphuric acid produces a precipitate. A white milkiness or opalescence may be caused by ferric oxide, chromic acid and some other bodies, such as chlorine, &c.	After addition of ammonium chloride and excess of ammonia, a precipitate is produced by ammonium sulphide.	Original solution gives white precipitate with sodium carbonate.	Not precipitated by preceding re-agents.
Silver Lead Mercury, in mercurous salts.	DIVISION I. Soluble in ammonium sulphide. Platinum—black Gold—black Tin in stannic salts—pale yellow Arsenic—yellow Antimony—orange	DIVISION I. Iron Cobalt } black Nickel DIVISION II. Manganese—buff Zinc—white Aluminum—white Chromium—greenish	Barium Strontium Calcium Magnesium	Potassium Sodium Ammonium
	DIVISION II. Soluble in the sulphide when boiled with sulphur. Tin in stannous salts—brown	If the salt of manganese is not pure, the colour of the precipitate may be not buff but dirty grey; the same with zinc and aluminum.		
As lead chloride is somewhat soluble in water, this metal may escape detection in dilute solutions, but will be found in the next Group.	DIVISION III. Insoluble in the sulphide. Lead—black Copper—black Mercury—black Bismuth—brown-black Cadmium—yellow	The aluminum precipitate (oxide) is often scarcely visible in dilute solutions until after standing some time.		
Tartar emetic will give a white precipitate soluble in excess of acid. Pass to Group II.		The chromium precipitate (oxide) is often greyish.		
Tungstates will give a white precipitate with hydrochloric acid, insoluble in excess, turning blue on the addition of metallic zinc, yellow by boiling with nitric acid, and soluble in ammonia after washing.				
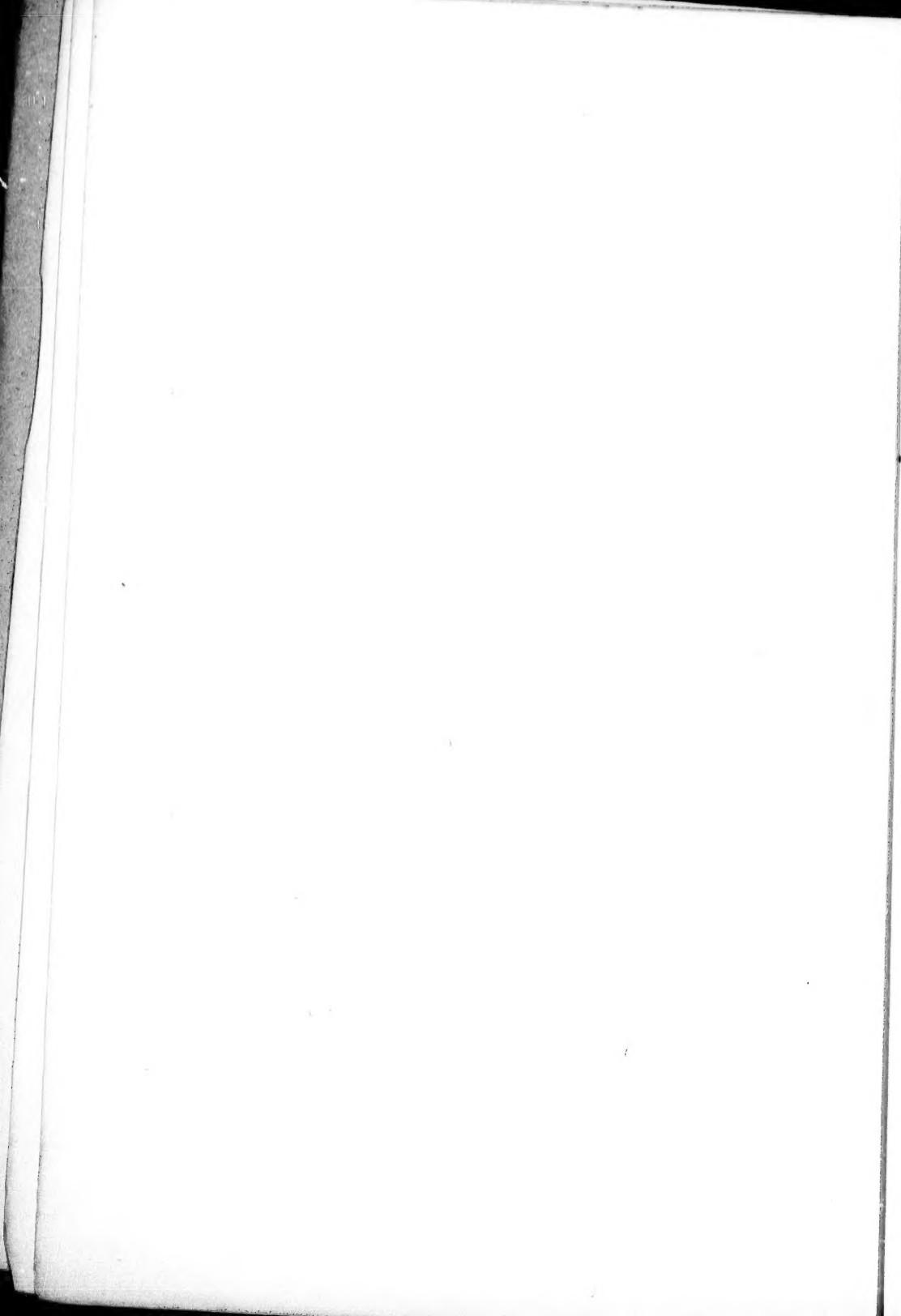
GROUP I.

The white precipitate is allowed to settle, the liquid poured off, washed with water by decantation, and ammonia added.

Precipitate dissolves.	Turns black or grey.	Remains almost unchanged.
Silver.	Mercury.	Lead.
Original solution gives a crimson precipitate with potassium chromate.	Solutions produce a grey stain on copper or gold, which volatilises on heating.	The original white precipitate formed by hydrochloric acid is soluble in a large quantity of boiling water. To try this, most of the precipitate should be poured off, and the residue boiled with much water.
Solution of ferrous sulphate produces a greyish precipitate of metallic silver.	The salts are volatile.	
	The white precipitate formed by hydrochloric acid, when boiled with excess of the same, turns greyish.	The original solution gives a yellow precipitate with potassium chromate, soluble in large excess of potassium hydrate. Only a small quantity of the yellow precipitate should be employed.
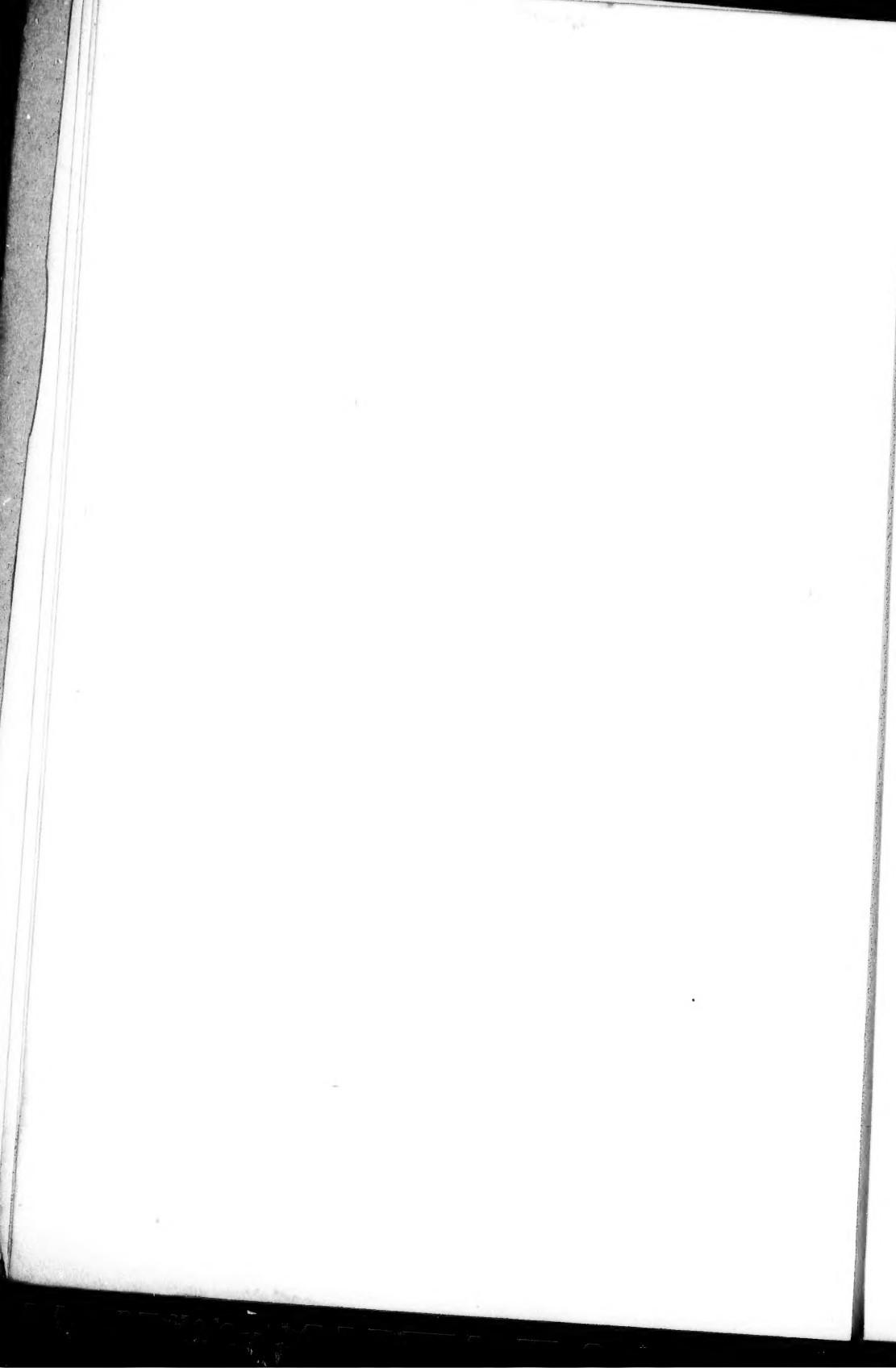
GROUP II.

To determine the solubility or insolubility of the precipitated sulphide in ammonium sulphide, it should be allowed to settle, the liquid poured off, and this operation repeated with pure water. The sulphide can then be added. If time allows, it is better to throw the precipitate on to a filter, wash with water, and treat with ammonium sulphide while on filter.

DIVISION I.

Precipitated sulphide is soluble and

Black.

Original solution gives, with hydrochloric acid and potassium chloride, a yellow precipitate. With potassium iodide, a dark colour.

Original solution gives, with ferrous sulphate, a brown precipitate, or a blue colour in *very* dilute solutions.

Orange.

The original solution, mixed with excess of hydrochloric acid and a piece of metallic zinc, gives a black flocculent deposit, partly on the zinc. Some of the acid solution placed on platinum in contact with zinc, gives a black stain.

Yellow.

The precipitate is soluble in ammonia.

The original solution gives no precipitate with potassium hydrate.

The precipitate is insoluble in ammonia if previously freed from excess of solution of hydrosulphuric acid.

The original solution gives a white precipitate with potassium hydrate, soluble in excess.

Platinum. Gold.   Antimony.   Arsenic.   Tin in stannic salts.

DIVISION II.

The precipitate is brown, and when treated as above, with ammonium sulphide, with the addition of a little powdered sulphur and the aid of heat, dissolves.

Original solution gives grey precipitate with mercuric chloride, if added in excess and warmed.

Tin in stannous salts.

GROUP II.—*(Continued.)*

DIVISION III.

The precipitated sulphides insoluble in ammonium sulphide, and is

Yellow.

Original solution gives with ammonia a white precipitate, soluble in excess. No precipitate with dilute sulphuric acid.

Cadmium.

Black.

Original solution gives with ammonia a white precipitate, insoluble in excess. With dilute sulphuric acid, a white precipitate.

Original solution gives with potassium hydrate a white precipitate, soluble in large excess. This test is preferable to that with ammonia, which produces no precipitate in the acetate unless used in great excess.

Original solution gives a yellow precipitate with potassium chromate, soluble in large excess of potassium hydrate.

Lead.

Black.

Original solution gives with ammonia a blue precipitate, soluble in excess to a fine blue solution. No precipitate with dilute sulphuric acid.

Iron introduced into an acid solution becomes coated with a red metal.

Original solution gives with potassium ferrocyanide, a brown red precipitate.

Copper.

Black.

Original solution gives with ammonia a white precipitate, insoluble in excess; with potassium hydrate, a yellow precipitate. No precipitate with dilute sulphuric acid.

Other tests as for mercurous salts.

Mercury in mercuric salts.

Brown-black.

Original solution gives with ammonia a white precipitate, insoluble in excess. No precipitate with dilute sulphuric acid. The salts, unless containing an organic acid, are decomposed by water, becoming opaque and falling to powder.

Original solution gives with potassium chromate a yellow precipitate, insoluble in excess of potassium hydrate.

Bismuth.

(Owing to above property, salts of this metal must be dissolved in water with the addition of a little nitric acid aided by heat.

Some salts of antimony, tin and mercury act in the same way.

GROUP III.

The black sulphide should be allowed to settle and washed several times with water, especially if nitric or chloric acid be present.

DIVISION I.

The addition of hydrochloric acid to the washed sulphide

Dissolves it.		Leaves it undissolved.	
Original solution gives with potassium hydrate or ammonia a brown precipitate. Organic acids interfere with these reactions.	Original solution gives with potassium hydrate or ammonia a dirty green precipitate, turning black and then brown.	Original solution gives with potassium hydrate a green precipitate, soluble in ammonia with a blue colour.	Original solution gives with potassium hydrate a blue precipitate, soluble in ammonia with a brown colour.
Iron in ferric salts.	Iron in ferrous salts.	Nickel.	Cobalt.

DIVISION II.

The precipitates are all soluble in hydrochloric acid, and their colours are

Greenish, or Grey.	Buff.	White.	White.
Original solution gives with potassium hydrate a green or grey precipitate, soluble in excess to a fine green solution.	Original solution gives with potassium hydrate a white precipitate, turning brown on exposure to the air.	Original solution gives with ammonia a white precipitate, soluble in excess.	Original solution gives with ammonia a white transparent precipitate, insoluble in excess.
Chromium.	Manganese.	Zinc.	Aluminum.

This colour is often not pure buff, but greyish, if the salt be not pure. The same is the case with the precipitate formed from zinc and aluminum solutions. The tests with potassium hydrate or ammonia will decide the point.

From acid solutions white precipitates may be formed, consisting of earthy phosphates, oxalates, &c
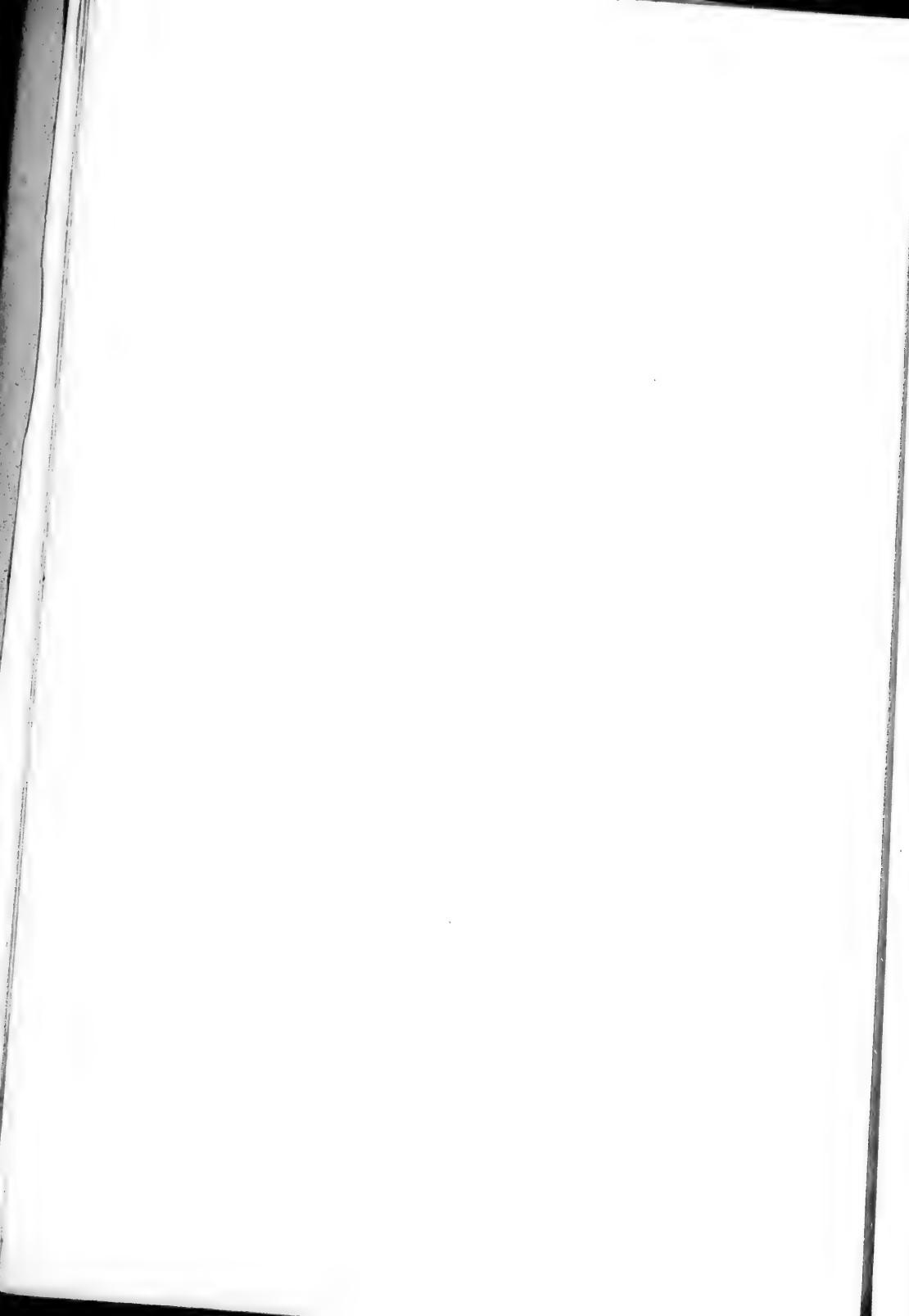
GROUP IV.

If the solution employed in the previous group tests is employed, that is, if salts of ammonia are present, it may be better to warm gently. With original solution this is not necessary.

The original solution, mixed with a large quantity of ammonium chloride and a moderate quantity of ammonium carbonate, gives

A white precipitate.			No precipitate.
Original solution gives, with calcium sulphate,			The addition of sodium phosphate produces a precipitate, crystalline when from dilute solutions.
A precipitate at once.	A precipitate after some time.	No precipitate.	
The salt colours the flame of alcohol—green.	The salt colours the flame of alcohol—crimson.	The salt colours the flame of alcohol—orange red.	
Barium.	Strontium.	Calcium.	Magnesium.

GROUP V.

Original solution, rather concentrated, and acidulated with hydrochloric acid, gives, with platinum tetrachloride,

A yellow precipitate.		No precipitate.
Dry salt, heated with potassium hydrate, evolves no ammonia.	Dry salt, heated with potassium hydrate, evolves ammonia.	Salts colour the flame of alcohol—yellow.
Dry salt colours the flame of alcohol— violet.	Salts are volatile, and do not colour the flame of alcohol.	
Potassium.	Ammonium.	Sodium.

If no metal is found, the substance is probably an acid, and the base hydrogen.

NOTES ON THE TABLES FOR ACIDS.

Free acids may be neutralised with potassium hydrate, the solution evaporated to dryness, and a salt thus obtained. This is not always necessary, but is required if the test of blackening by heat is to be tried. To avoid this trouble, a second arrangement for acids is appended in Table III.

Acid salts may be rendered neutral by adding a little ammonia till solution is alkaline; and by heating, any excess of ammonia may be removed.

Silicic acid, being insoluble in water, and all acids except hydrofluoric, must be dissolved by boiling in sodium hydrate or carbonate. The sodium compounds are preferable to those of potassium, as the latter generally contain silicic acid.

In testing for tartaric and citric acids by means of lime water, a very large quantity of the latter must be used, especially if it is the free acid under examination. The lime water must be added till an alkaline reaction is produced.

Before testing a salt, it should be tried as to its neutrality or acidity by means of litmus paper.

Some acid salts can be neutralised by ammonia without any precipitate being formed; but some metallic oxides cannot form salts neutral to test paper, and in these the smallest quantity of ammonia may produce a precipitate.

In some cases, barium nitrate must be used instead of the chloride; as lead, silver, and mercurous salts would give precipitates of chlorides.

In all cases of testing for bases or acids, after the application of the tests contained in the group tables, the student should make a number of confirmatory experiments with other re-agents.

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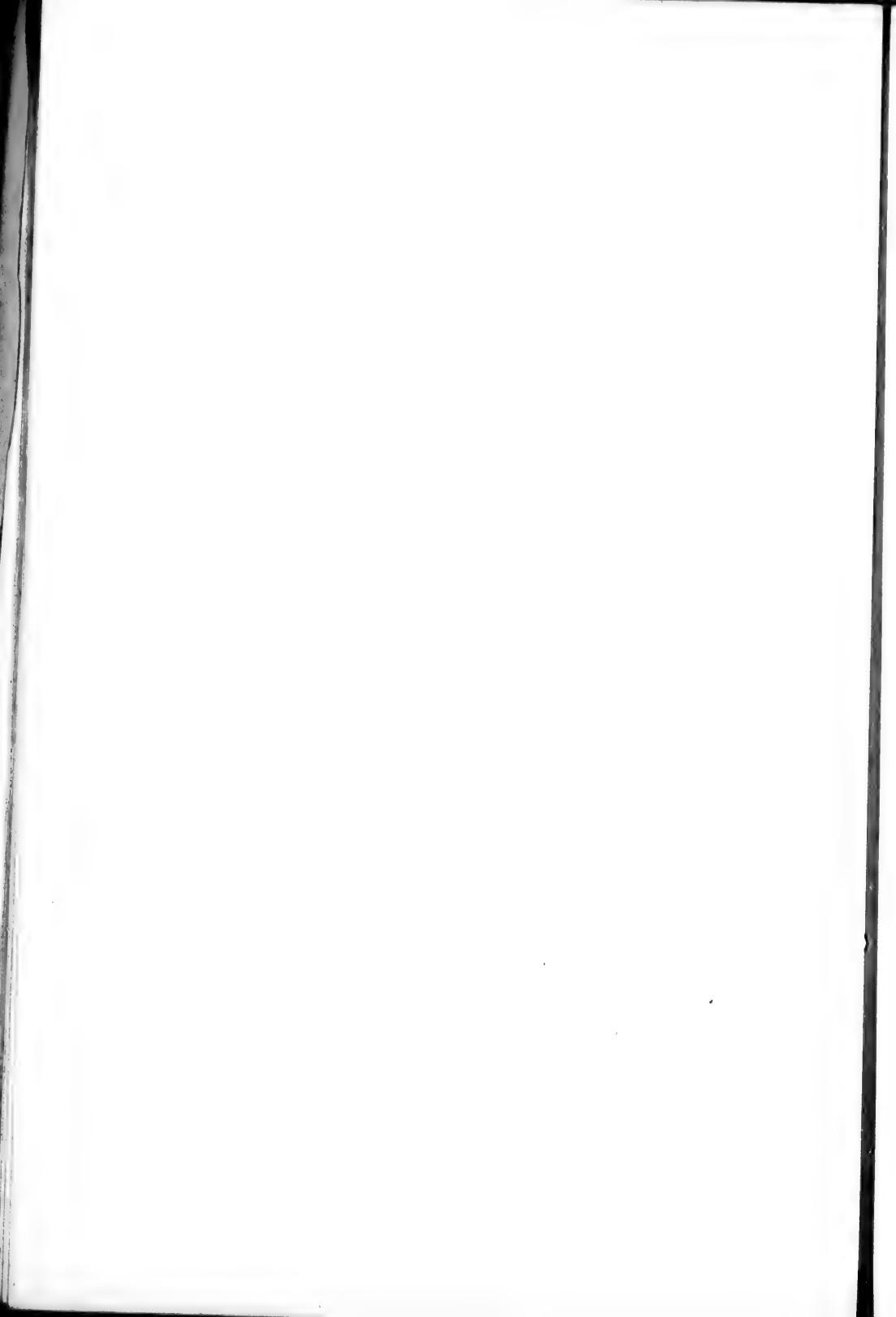
TABLE II.—FOR ACIDS OR ACID RADICLES.

In testing for acids, the solutions employed should be neutral; or if not so, when the salt or acid is dissolved, should be rendered neutral or slightly alkaline by the careful addition of ammonia.

GROUP I.	GROUP II.	GROUP III.	GROUP IV.
The dry salt when heated rapidly in a closed tube.	Not blackening when heated in a tube, but deflagrating on charcoal.	Not blackening or deflagrating. Original solution gives a precipitate with barium chloride or calcium chloride.	Not blackening or deflagrating. Original solution gives a precipitate with silver nitrate, but none with barium chloride.
DIVISION I, Blackens strongly. Tartaric Citric Tannic Gallic Acetic Benzoic **DIVISION II.** Blackens slightly, becoming grey or brown. Oxalic Hydroferrocyanic Hydroferricyanic Sulphocyanic Several inorganic salts become darker on heating. Not applicable to salts of ammonia.	Nitric Chloric Iodic Bromic acid is not likely to occur.	Sulphurous Sulphuric Phosphoric Boracic Silicic Carbonic Hydrofluoric (Oxalic) 1st Group Chromic Arsenious Arsenic Antimonic (Iodic) 2nd Group Ferrocyanic (if solutions are rather strong) Oxalic is included in this group, as its salts blacken very slightly. Barium borate is somewhat soluble, and the silicate and fluoride are often gelatinous and not very visible	Hydrochloric Hydriodic Hydrobromic Hydrocyanic Hydrosulphuric (Hydroferrocyanic) in dilute solutions Hydroferricyanic Sulphocyanic (Acetic) in rather concentrated solutions
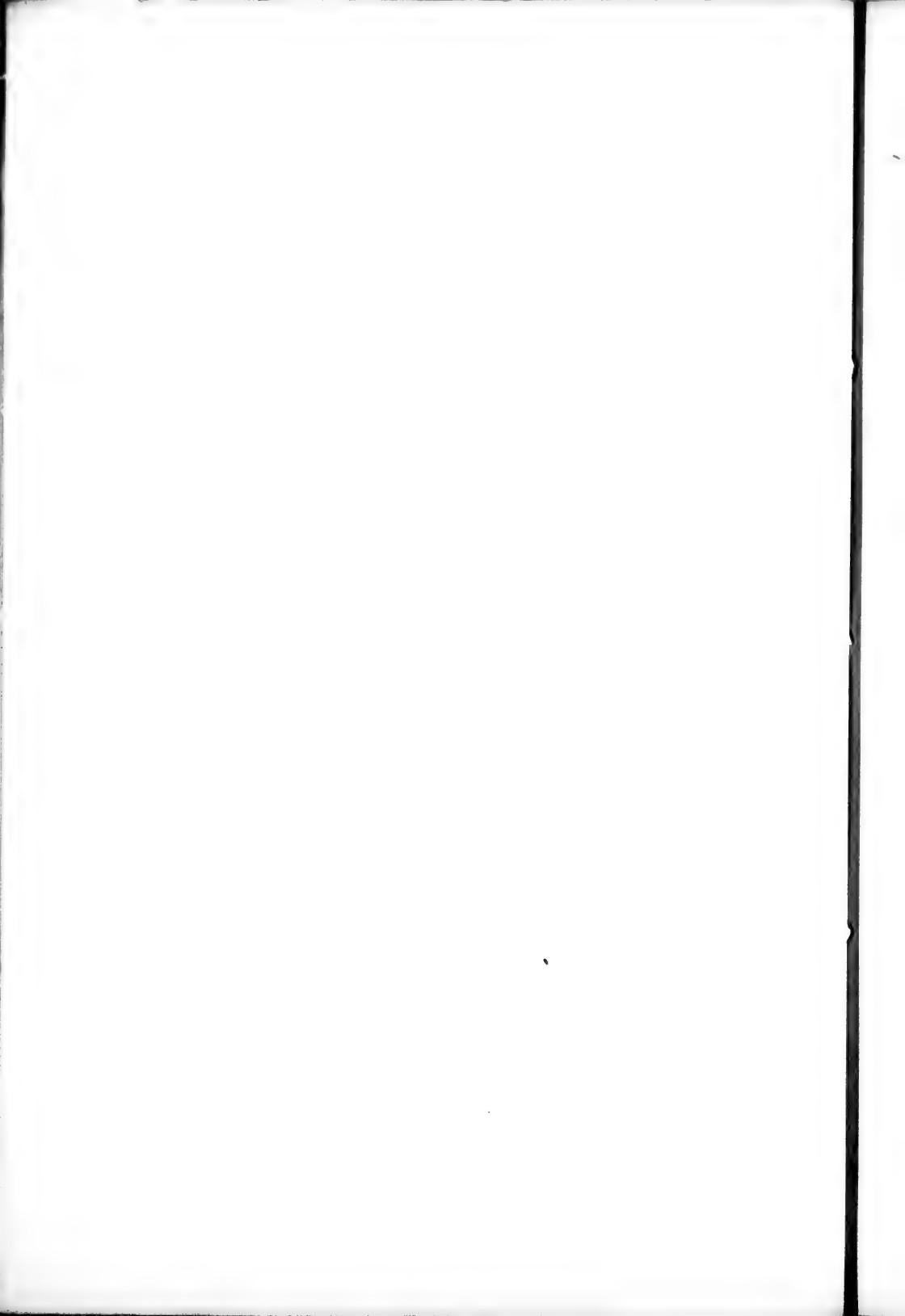
GROUP 1.

DIVISION I.

Dry salt, when heated, evolves smell of burnt sugar; heated with strong sulphuric acid, blackens rapidly. The original solution, with excess of lime water, gives a white precipitate, soluble in large excess of potassium hydrate; boiled with silver nitrate, becomes turbid and black.

Tartaric.

Dry salt, when heated, evolves an acid smell; heated with sulphuric acid, blackens slowly. Solutions give a white precipitate, with excess of lime water; insoluble in ammonia.

Citric.

Salt or acid blackens rapidly when heated with sulphuric acid; gives black colour with ferric chloride; precipitates gelatine.

Tannic.

Salt or acid blackens rapidly when heated with sulphuric acid; gives black colour with ferric chloride; does not precipitate gelatine.

Gallic.

Dry salt, heated with sulphuric acid, evolves smell of vinegar. Original solution gives, with ferric chloride, a red colour, and red brown precipitate on boiling.

Acetic.

Dry salt, heated with sulphuric acid, evolves pungent vapours of an aromatic odour. Original solution gives buff precipitate with ferric chloride.

Benzoic.

Dry salt or acid, heated in a porcelain capsule with a few drops of nitric acid and the solution evaporated to dryness, gives a red residue, which dissolves in potassium hydrate with a purple colour.

Uric.

DIVISION II.

Salts blacken very slightly on heating; the residue dissolves in acids with effervescence. Dry salt or acid, heated with strong sulphuric acid, evolves a gas which burns at the mouth of the tube with a blue flame.

Salt or acid, mixed with manganese dioxide and sulphuric acid, produces violent effervescence.

Oxalic.

Salts turn brown on heating; heated with sulphuric acid, turn blue, and evolve hydrocyanic acid. The solutions give a pale blue precipitate with ferrous salts; a dark blue with ferric salts.

Hydroferrocyanic.

Salts turn brown on heating. Solutions give a dark blue precipitate with ferrous salts; a brown colour with ferric salts.

Hydroferricyanic.

Salts turn somewhat dark on heating. Solutions give a red colour with ferric chloride; not altered by boiling, but destroyed by mercuric chloride.

Sulphocyanic.

The acids of this division, as well as acetic acid, will appear in other groups.
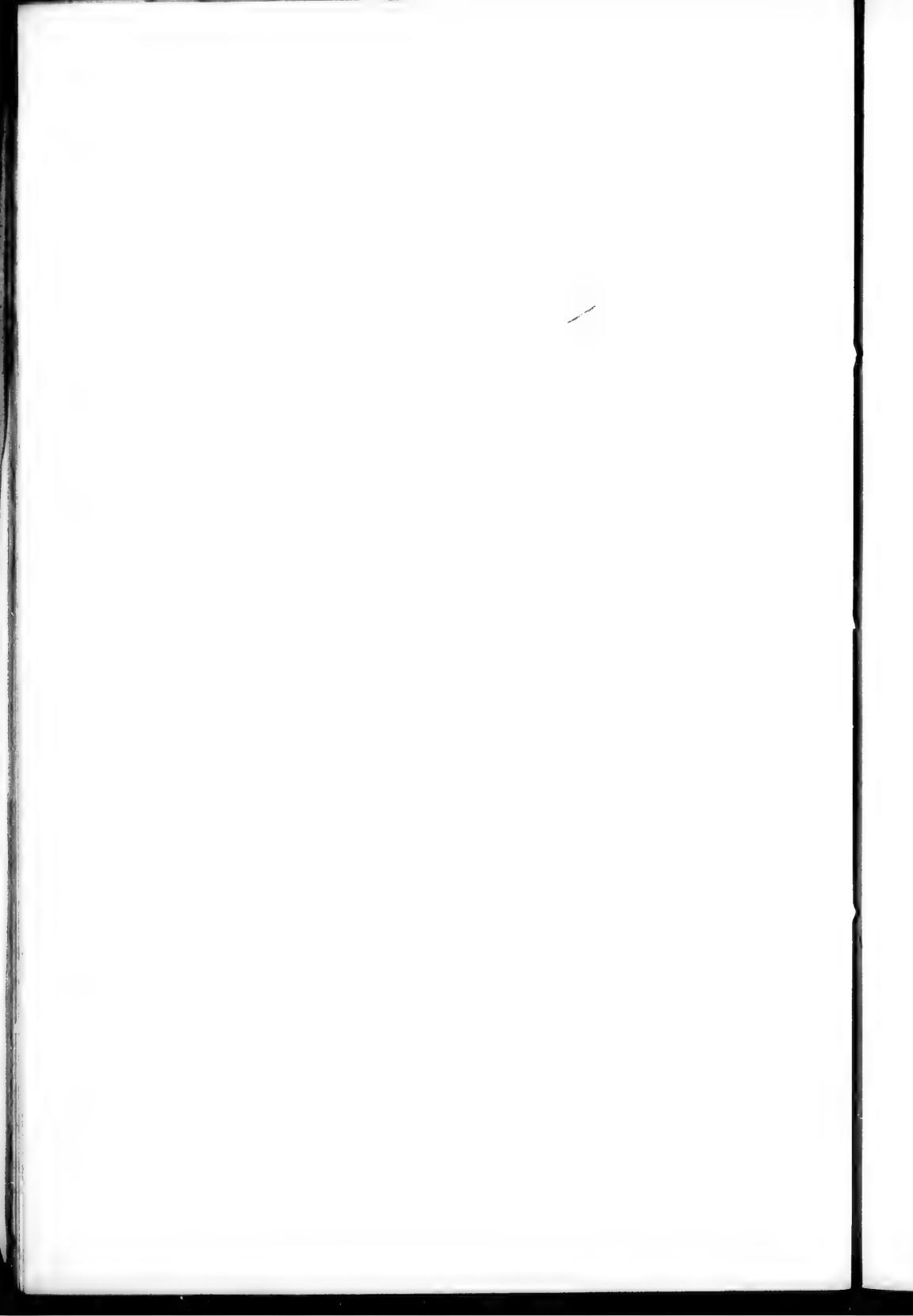
GROUP II.

Salts heated with sulphuric acid and metallic copper give off red fumes; heated with sulphuric acid and solution of indigo, turn the blue colour to brown.

Nitric.

Salts heated with sulphuric acid give off an explosive gas; act on indigo in the same way as nitrates. Their solutions give no precipitate with silver nitrate; but after being strongly heated, the residue, when dissolved, gives a white precipitate with silver nitrate.

Chloric.

Salts deflagrate on charcoal, evolving violet-coloured fumes. Solutions mixed with starch-paste and sulphurous acid produce a blue colour. Solutions give a white precipitate with barium chloride.

Iodic.
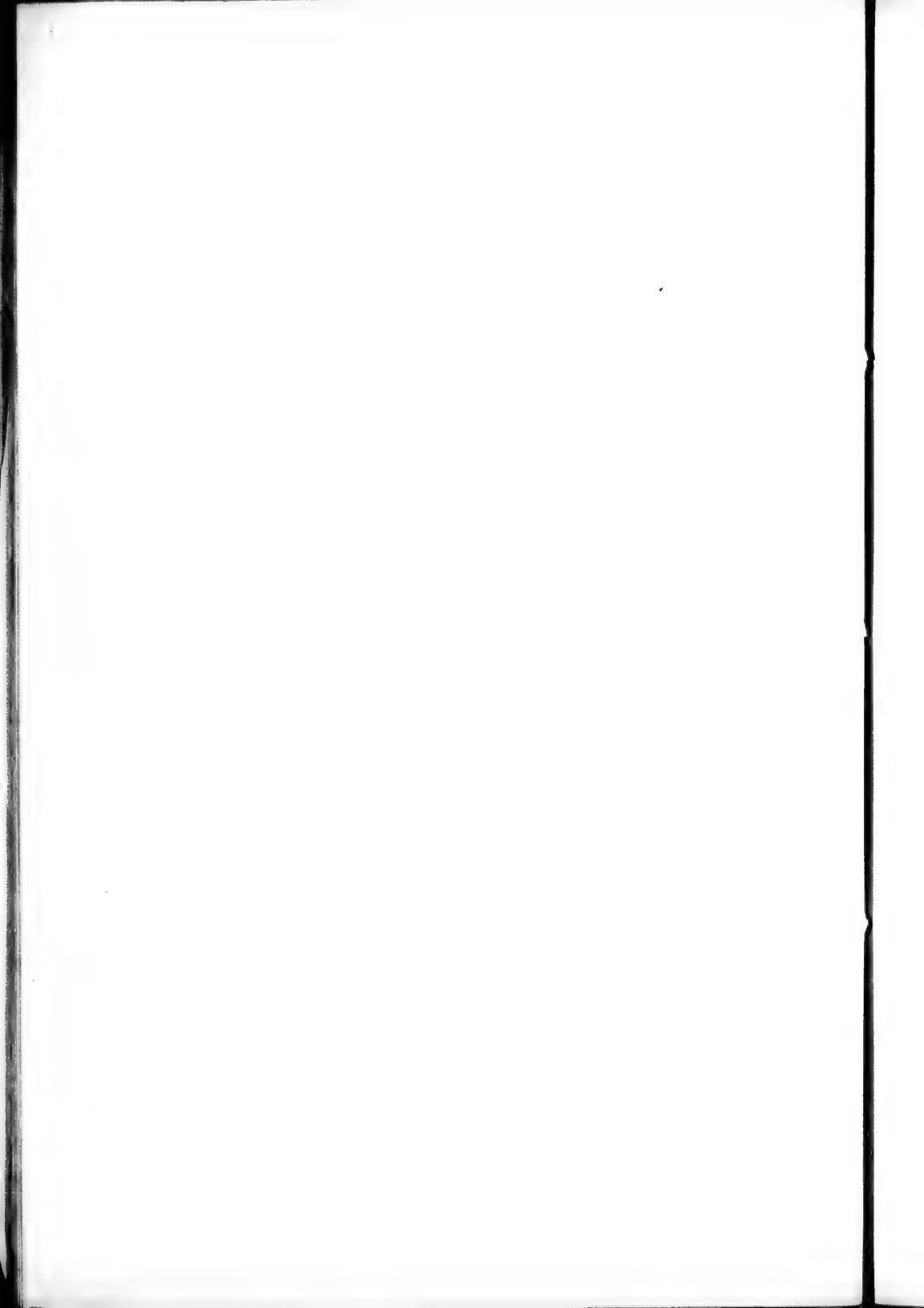
GROUP III.

DIVISION I.

Salts, or solutions, mixed with tolerably strong sulphuric acid, evolve a gas

Without smell.

The gas decanted into a tube containing lime water and shaken, gives a white precipitate.

Carbonic.

With smell of burning sulphur.

The gas acts upon iodic-starch paper, producing a blue colour.

Sulphurous.

...ells of rotten eggs.
...p IV.

Hydrosulphuric, or Sulphur.

DIVISION II.

Salts or solutions mixed with tolerably strong sulphuric acid do not evolve a gas :

Solutions of salts give a precipitate with barium chloride.

Insoluble in nitric acid.

The salt fused on charcoal with sodium carbonate, produces a red mass, which when placed on a silver coin and moistened with water, produces a brown stain.

Sulphuric.

Soluble in nitric acid.

Solutions of salts give with calcium chloride a precipitate.

Insoluble in acetic acid.

Salts heated with sulphuric acid evolve a gas which corrodes glass.

Hydrofluoric.

For oxalic and hydroferro-cyanic acids, see Group I.

Soluble in acetic acid.

Salts give yellow precipitate with silver nitrate, a yellow precipitate on heating with ammonium molybdate.

Phosphoric.

Salts treated with excess of sulphuric acid give a green colour to flame of alcohol. Copper and barium must not be present.

Boracic.

Salts give a gelatinous precipitate with hydrochloric acid, seen better by evaporating to dryness, and washing with water when it remains undissolved.

Silicic.

Salts are yellow, red or brown, give a crimson precipitate with silver nitrate, boiled with alcohol and sulphuric acid, give a green solution with or without an insoluble residue.

Chromic.

For arsenious, arsenic and antimonic acids, see Bases. For iodic, see Group II.

NOTE.—In ammoniacal solutions of tartrates, calcium chloride forms a flocculent precipitate which soon becomes crystalline and insoluble in acetic acid. It might be mistaken for oxalate, but this salt is soluble in hydrochloric acid, and reprecipitated by ammonia, while tartrate of calcium is not so precipitated. The blackening by heat is also characteristic.
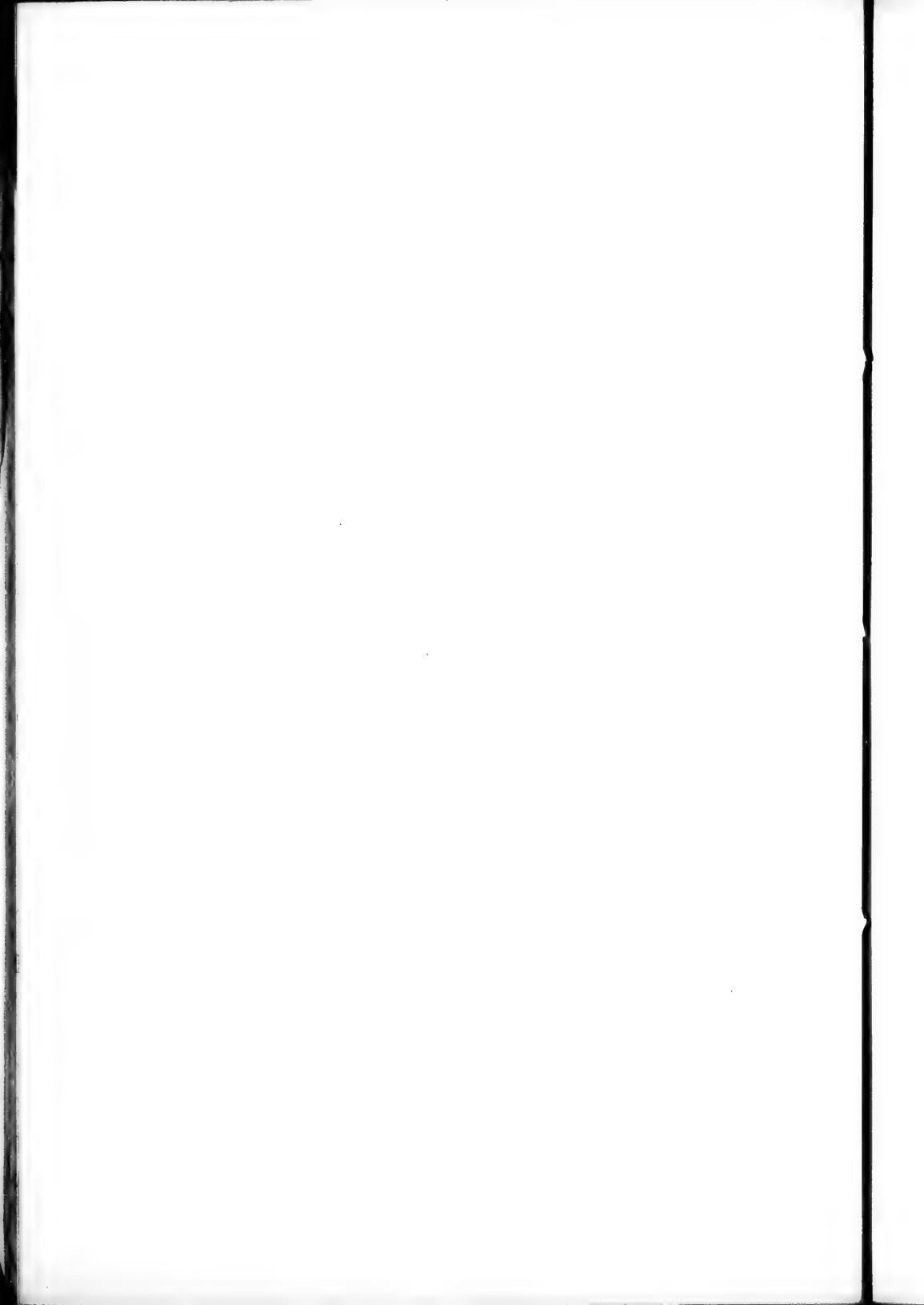
GROUP IV.

Precipitate with silver nitrate is insoluble in dilute nitric acid and

Black.

Soluble salts give purple colour with sodium nitroprusside, black precipitate with lead, evolve bad smelling gas when treated with acids; the gas blackens lead paper.

Compounds insoluble in water, when heated with nitric acid, evolve red fumes, and the solution obtained contains sulphuric acid.

Hydrosulphuric acid or sulphur.

Yellowish.

Insoluble in ammonia.

Salts heated with sulphuric acid give off violet fumes.

Solutions treated with chlorine water become yellow; the solution turns starch paste blue; shaken with carbon disulphide communicates to it a pink or dark colour.

Hydriodic or iodine.

Soluble in warm ammonia.

Salts heated with sulphuric acid give off yellow, bad-smelling fumes.

Solutions treated with chlorine water and shaken with ether, communicate to it a yellow colour.

Hydrobromic or bromine.

Brownish Yellow.

Hydroferricyanic. See Group I.

White.

Salts heated with manganese dioxide and sulphuric acid evolve chlorine, recognisable by its odour and its bleaching properties.

Salts heated with sulphuric acid alone, evolve the pungent fumes of hydrochloric acid, which form dense clouds with ammonia.

Hydrochloric.

Salts heated with sulphuric acid evolve vapours of hydrocyanic acid recognisable by odour, and by being absorbed by a few drops of ammonium sulphide held over them on a watch glass; on evaporating to dryness the residue gives a blood red colour with ferric chloride. Solutions mixed with ferrous and ferric chlorides, then potassium hydrate and then hydrochloric acid, give a blue colour.   Hydrocyanic.

Salts give a precipitate only in rather concentrated solutions.

Heated with alcohol and sulphuric acid evolve sweet smelling vapours of acetic ether.

Solutions give with ferric chloride a red colour, destroyed by boiling but not by mercuric chloride.

Acetic.

Meconic acid gives a similar red colour with ferric chloride not destroyed either by boiling or mercuric chloride.

Sulphocyanic acid, see Group I.
Hydrofluoric acid, see Group III.
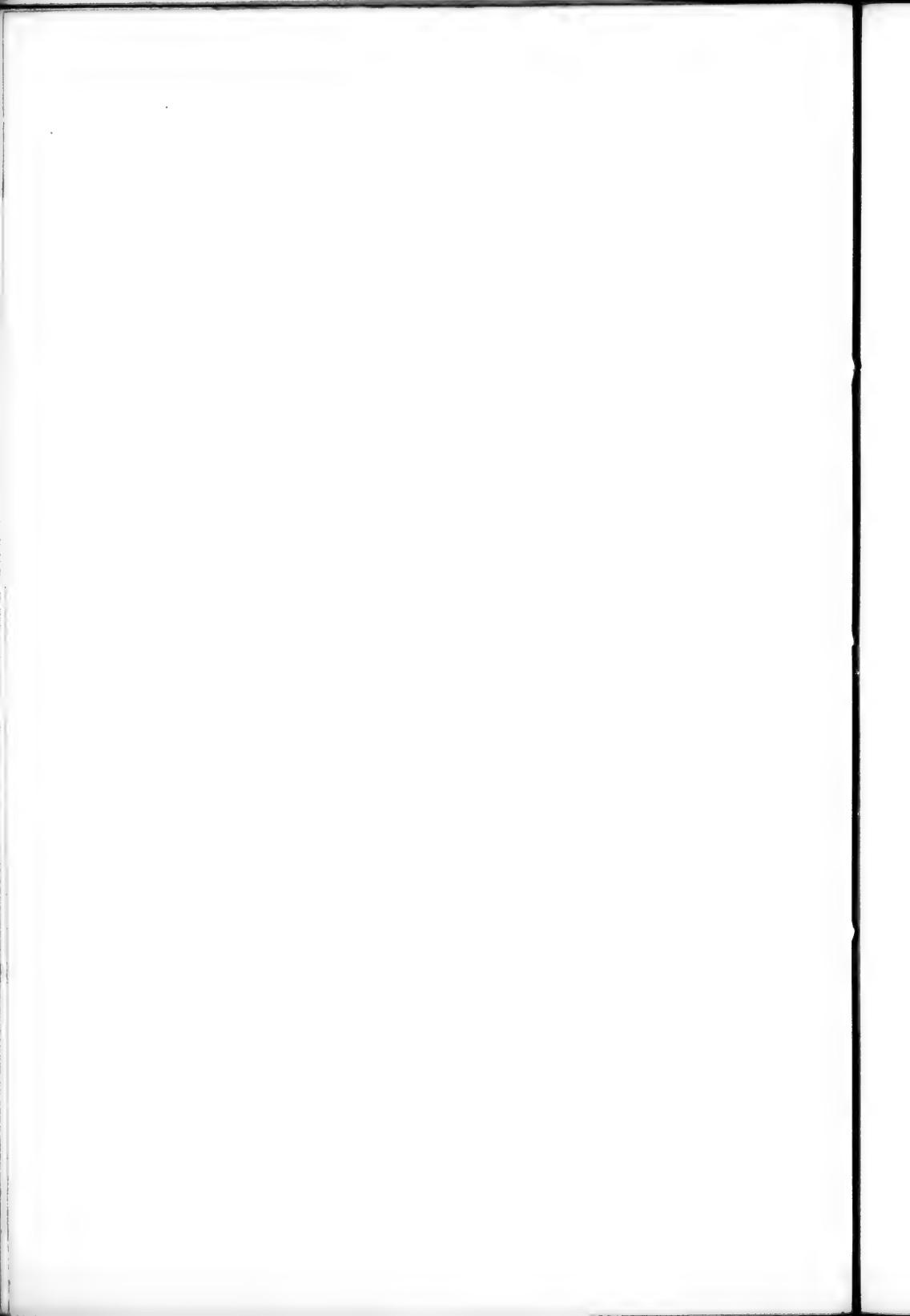
TABLE III.

This table may be used when solutions are to be examined, in order to avoid the trouble of evaporating. Also when ammonium has been found in the examination for bases, the presence of which would prevent the test of blackening by heat, salts of ammonium being volatile. A fresh solution must be used for each column, and the acid thus reduced to a small group.

Precipitated from neutral solutions by barium chloride.	Precipitated from neutral solutions by calcium chloride.	Precipitated from neutral solutions by silver nitrate.	Neutral solutions with ferric chloride give	Salts deflagrate on charcoal.
Precipitate insoluble in nitric or hydrochloric acid.	Precipitated at once. Insoluble in acetic acid.	Insoluble in dilute nitric acid. Black.	White precipitate.	Chloric
Sulphuric	Hydrofluoric	Hydrosulphuric	Phosphoric	Nitric
Soluble in nitric or hydrochloric acid	Oxalic	White.	Blue precipitate.	Iodic
With effervescence.	Hydroferrocyanic	Hydrochloric	Hydroferrocyanic	
Carbonic	Soluble in acetic acid.	Hydrocyanic	Brown colour.	
Sulphurous	Carbonic	Hydroferrocyanic	Hydroferricyanic	
Hydrosulphuric	Phosphoric	Sulphocyanic	Red colour.	
Without effervescence.	Boracic	Yellowish.	Acetic	
Phosphoric	Tartaric	Hydriodic	Sulphocyanic	
Boracic	Arsenious	Hydrobromic		
Oxalic	Arsenic	Yellow-brown.		
Hydrofluoric	Precipitated after boiling	Hydroferricyanic		
Tartaric	Citric	Soluble in nitric acid.		
Citric		White.		
Chromic		Carbonic		
Arsenious		Boracic		
Arsenic		Oxalic		
		Tartaric		
		Citric		
		Yellow.		
		Phosphoric		
		Arsenious		
		Red brown.		
		Chromic		
		Arsenic		

SUBSTANCES INSOLUBLE IN WATER, BUT SOLUBLE IN HYDROCHLORIC ACID OR AQUA REGIA.

Many metals are soluble in hydrochloric acid, others in nitric acid. Tin and antimony are converted into insoluble oxides by nitric acid, but can be dissolved by hydrochloric with a little nitric. Many insoluble metallic compounds may be decomposed by digestion with ammonium sulphide; the solution will contain the acid radical, and the residue the metallic sulphide: this can be dissolved in nitric acid, and the two solutions examined for acid and base.

Mercuric sulphide must be dissolved in aqua regia.

Many sulphates, all phosphates, borates, oxalates, silicates, and some fluorides, iodides, and bromides, may be dissolved in hydrochloric or nitric acid, and examined for acid and base by appropriate tests; —insoluble cyanides, by acting on them with sulphuric acid and absorbing the vapours by a watch glass moistened with ammonium sulphide, and proceeding as described for hydrocyanic acid.

Salts of organic acids are best decomposed by boiling with sodium carbonate, filtering and washing; the residue of carbonate may be dissolved in acid and tested for base; the filtrate must be neutralised with nitric and tested for acid or acid radicle. Many salts of inorganic salts may be examined in the same way.

All nitrates and acetates are soluble in water, except a few basic salts.

All the salts of potassium, sodium and ammonium are soluble more or less—the platino-chlorides of the first and third nearly insoluble. Silico-fluoride of potassium is insoluble.

Carbonates and sulphites will dissolve in acids with effervescence; the gases evolved can be distinguished by tests already described. Phosphates, borates, &c., will dissolve without effervescence.

Oxalates, when heated, turn grey if previously white; they dissolve in acids without effervescence before heating, but with effervescence after: the same may be said of the salts of all organic acids. In many cases, however, where the base has no great tendency to retain carbonic acid, no effervescence will be caused by the action of acid on the heated residue, as only oxide remains behind; e. g., oxalates of chromium, iron, manganese, &c. In these oxalates, tartrates and citrates,
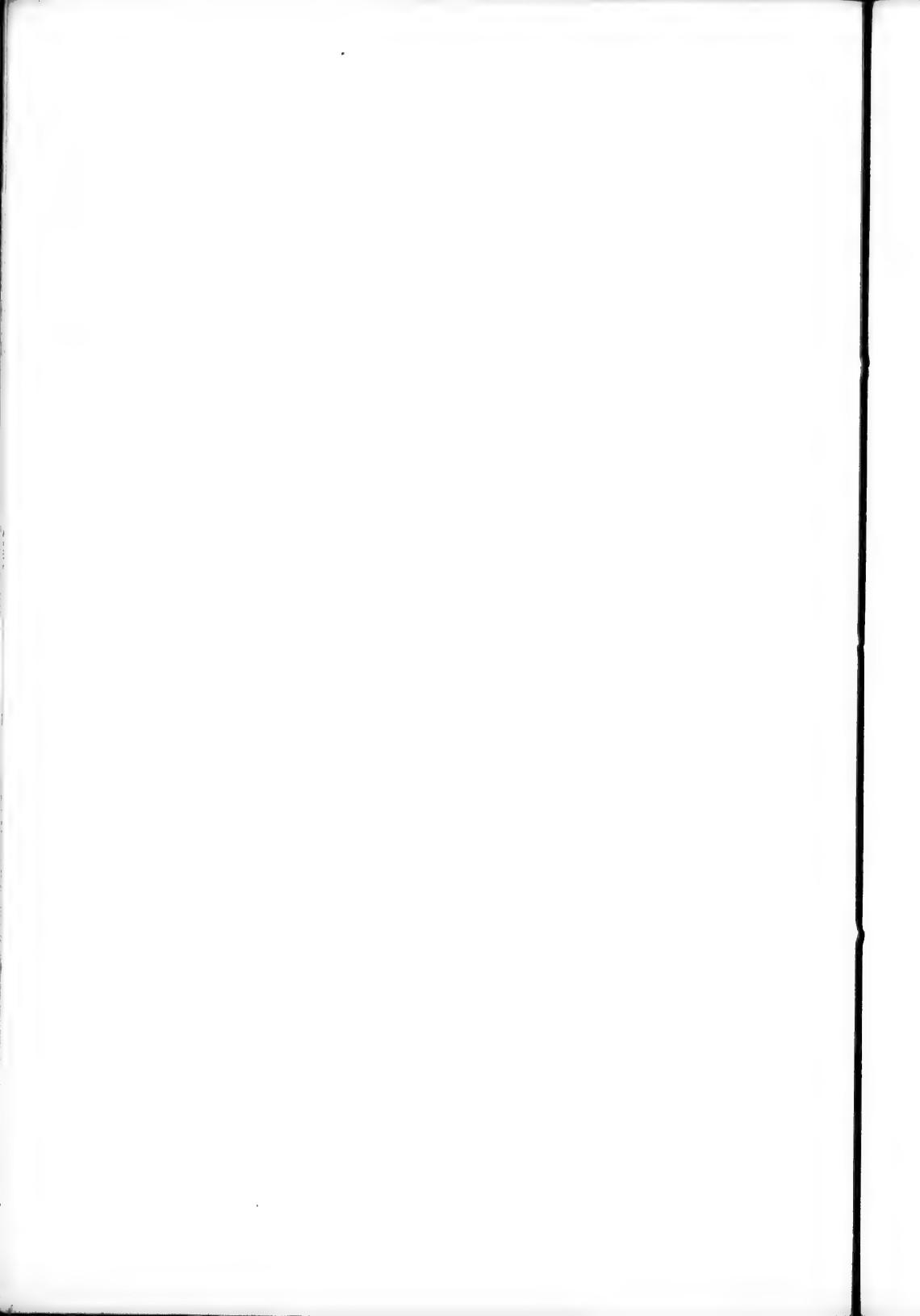
the chromium, iron, &c., cannot be detected by the ordinary tests, such as ammonia or potassa; the salt must be heated to redness, the residue dissolved by long digestion in hydrochloric or sulphuric acid, and the solution tested for the metal. The oxalic acid also, cannot be detected by calcium chloride, as the chromo-calcium oxalate is soluble in water; the test with sulphuric acid, or the same acid with manganese dioxide, must be resorted to. The same applies to the double tartrates and citrates; these must be decomposed by treating with hydrosulphuric acid. All the tartrates can be recognised by the peculiar smell evolved on heating.

Chromates insoluble in water may be recognised by the action of hydrochloric acid and alcohol, which give a green solution containing oxide of chromium; the metal may remain partly undissolved as with lead, or may be held in solution, precipitable in some cases by hydrosulphuric acid. In the case of zinc and similar metals not so precipitable, the chromate must be decomposed by boiling or fusing with sodium carbonate.

Arsenites and arsenates may be decomposed by boiling or fusing with sodium carbonate, when the acid combined with sodium may be washed out, the oxide or carbonate remaining behind; or the salt may be dissolved in acid, treated with hydrosulphuric acid, when the sulphide of arsenic will be precipitated, free from metals of Groups III. and IV., but mixed with sulphides of metals of Groups I. and II. These sulphides can of course be separated by ammonium sulphide, but the process with sodium carbonate is preferable. Phosphates, borates, oxalates, &c., of metals of Groups I., II. and III. may be dissolved in acid, treated with hydrosulphuric acid or ammonium sulphide; the solution, after digestion, will contain the acid, the residue the metal as sulphide.

The phosphates, &c., of metals of Group IV. are best examined by boiling or fusion with sodium carbonate. Many may be examined directly. See apatite, among tests for minerals.

Calcium sulphate, when in fine powder, will dissolve in boiling water, and the base and acid can be detected in the solution; strontium sulphate dissolves very slightly in water; the sulphuric acid can be detected in the solution by barium chloride. Barium sulphate is quite insoluble. These sulphates are best examined by boiling or fusing with sodium carbonate, separating the earthy carbonate by washing, dissolving in acid, and applying proper tests; the filtrate can be examined for sulphuric acid after neutralisation.

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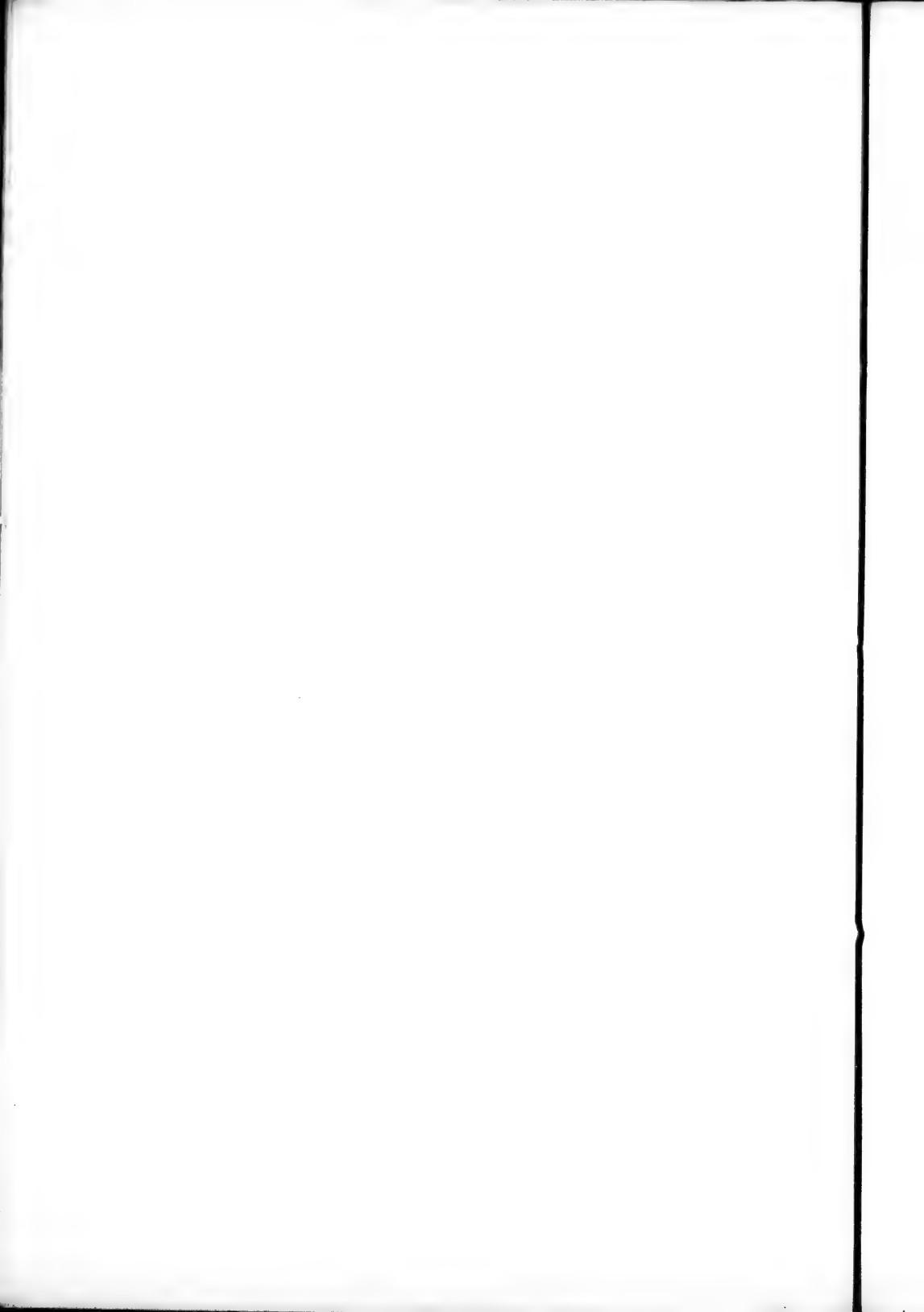
Lead sulphate may be examined in the same way, and distinguished at once from the above by turning black with ammonium sulphide. The insoluble chloride, iodides, and bromide of mercury may be examined by treating with ammonium sulphide, or by boiling with sodium hydrate or carbonate. Calomel will dissolve when heated with nitric acid or aqua regia. The iodine, chlorine and bromine in the silver compounds can be separated by fusing with sodium carbonate.

Tin tetroxide must be fused with potassium cyanide, the resulting metal dissolved in dilute hydrochloric acid, and the metal detected by appropriate tests.

## TESTS FOR SOME OF THE MORE COMMONLY OCCURRING MINERALS.

SHELL MARL.—By washing with water and pouring off the lighter particles, fragments of shells may readily be detected. The mineral dissolves readily in dilute nitric acid, gives a precipitate with oxalic acid and ammonia; the precipitate, separated after warming, filtration, and the filtrate tested for magnesia by means of sodium phosphate. The nitric solution heated with ammonium molybdate may give (rarely) a faint yellow precipitate or colour, owing to presence of phosphate.

LIMESTONES may be examined in the same manner; many contain magnesia (Rockwood). They sometimes contain bituminous matter, which causes them to evolve a disagreeable smell when pounded or heated.

CALCSPAR is generally met with in the rhombic or the scalenohedral form; effervesces even with weak acids; can be scratched with a knife.

FLUORSPAR is usually crystallised in cubes; treated with sulphuric acid evolves a gas which corrodes glass; cannot be scratched with a knife.

APATITE—Caicium phosphate—is usually of a greenish or reddish colour; occurs generally in six-sided prisms; when in powder dissolves readily in nitric acid. The phosphoric acid can be detected by heating the solution with ammonium molybdate, when a yellow precipitate is formed; or by adding silver nitrate to a solution obtained by boiling an excess of the mineral with a very little nitric acid, a yellow pre-

cipitate will be formed. The addition of ammonia dissolves the silver phosphate, but of course precipitates the original salt. The lime can be detected by adding oxalic acid and excess of sodium acetate to the acid solution. A light coloured pyroxene is often mistaken for apatite, readily distinguished by being much harder, and quite insoluble in nitric or hydrochloric acid.
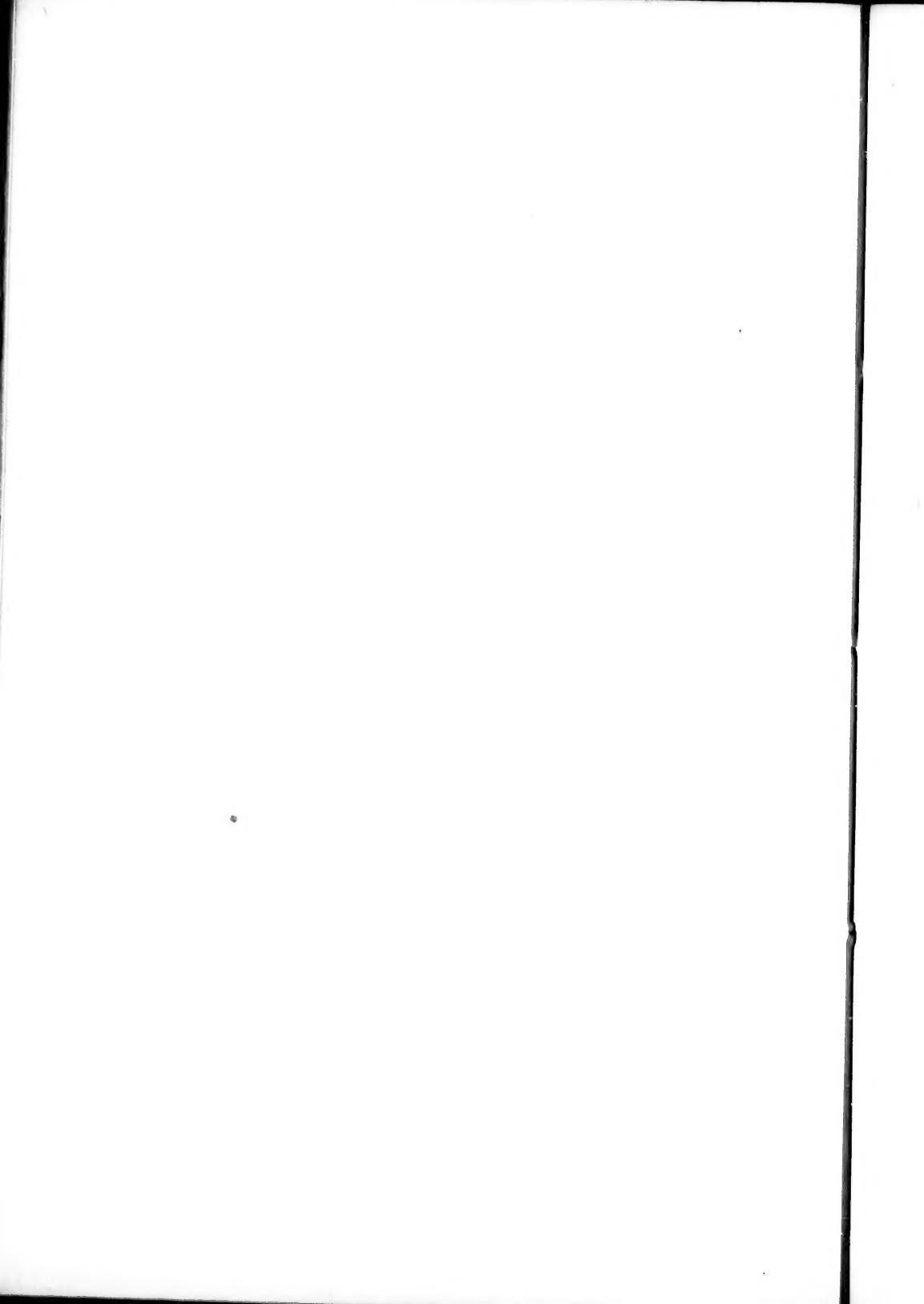
HÆMATITE—Ferric oxide—is not magnetic; when in fine powder dissolves in hydrochloric acid. The addition of nitric acid to the hot solution does not change its odour. The iron can be detected by usual tests; the ore gives a brown red streak on rough porcelain.

MAGNETIC IRON ORE.—Attracted by the magnet, the hydrochloric solution turns first black on the addition of nitric acid, and then brownish yellow. Ore gives a black streak.

TITANIC IRON ORE.—Scarcely attracted by the magnet; dissolves in hydrochloric acid only when very finely pounded. The titanic acid is best detected by fusing with an excess of potassium bisulphate; dissolving in a large quantity of cold water and boiling for a long time, a white or yellow precipitate is formed.

SULPHIDES, with the exception of cinnabar (mercuric sulphide, not occurring in Canada), are acted on by nitric acid, red fumes are evolved, and the solution contains sulphuric acid. In the case of galena (lead sulphide), the sulphuric acid remains combined with the lead oxide, as insoluble lead sulphate. (See Galena.) The sulphur can generally be detected by heating a portion of the ore in a tube, open at both ends, held slanting, and testing the gas evolved by iodic starch paper. Some sulphides, such as those of zinc, antimony and bismuth, may be dissolved in hydrochloric, with evolution of hydro-sulphuric acid, and the solutions examined by the proper tests.

IRON PYRITES, or iron bisulphide, when heated strongly before the blow-pipes, loses sulphur and forms a globule of iron sulphide, which is attracted by the magnet. The powdered ore is readily dissolved by nitric acid, which is not the case with gold, for which this ore is often mistaken. Gold will dissolve in aqua regia; while so-called golden mica, often mistaken for the metal, will not.

COPPER PYRITES, when gently roasted, moistened with hydrochloric acid, and exposed to the outer flame of the blow-pipe, will impart to it a bluish green colour. The ore may be dissolved in nitric acid, the solution treated with excess of ammon'·. A brown precipitate of ferric oxide will be formed, and a blue solution obtained.

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GALENA—Lead sulphide—when heated strongly on charcoal, will give a soft malleable bead of metallic lead, which may be dissolved in hot dilute nitric acid. The proper tests can then be applied to this solution.

CHROMIC IRON ORE, when fused with sodium carbonate and nitrate, or nitre, gives a yellow mass in which chromic acid may be detected.

GRAPHITE, when roasted, slowly burns away, leaving generally an earthy residue, insoluble in ammonia.

MOLYBDENITE, when roasted, gradually loses its dark colour, leaving a yellowish residue, which dissolves partly in ammonia. The molybdic acid can be detected by sodium phosphate (see page 13), or by blue colour produced by zinc and hydrochloric acid.

COPPER NICKEL.—Arsenide of nickel, of a red or copper colour, when heated in a tube open at both ends, and held in a slanting position, produces a white crystalline sublimate of arsenious acid. The residue, or the mineral itself, dissolved in nitric acid by the aid of heat, diluted, filtered and treated with hydrosulphuric acid, yields a yellow precipitate of arsenic sulphide; the filtrate is green, and gives the usual reactions of nickel. In some samples from mines on Lake Superior, the ore is mixed with metallic silver, sometimes in large quantities; the nitric solution will then give a precipitate with hydrochloric acid.

MISPICKEL, ARSENIDE AND SULPHIDE OF IRON.—The ore is of a whitish colour. When treated in a close tube gives a dark brown, or metallic ring if arsenic; if heated in an open tube gives a sublimate of arsenious acid, as above. Dissolves in nitric acid; the solution may be freed from arsenic by means of hydrosulphuric acid, and the filtrate tested for iron in the usual manner.

SILICIC ACID—Quartz—can be dissolved in fusing sodium carbonate with effervescence; the fused mass dissolved in water, the addition of hydrochloric acid will cause a gelatinous precipitate, or the acid solution may be evaporated to dryness, and washed with water; the silicic acid remains undissolved.

The above examples may serve as practice for the beginner. For plans for discriminating all the ordinarily occurring minerals, consult Chapman's " Minerals of Canada."